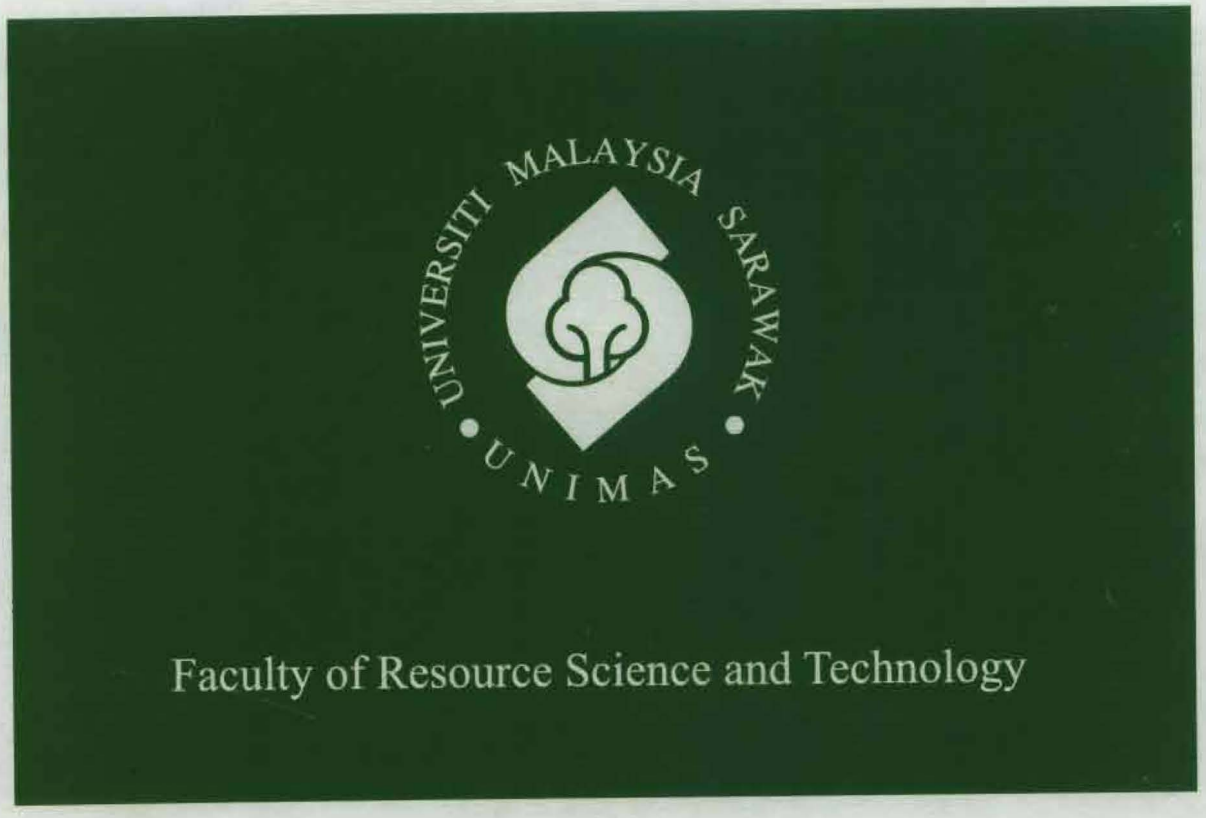

Water and Sediment Quality of Baram River

Chua Lee Wern

(40932)

Bachelor of Science with Honours
(Resource Chemistry)
2016

Water and Sediment Quality of Baram River

Chua Lee Wern

(40932)

A thesis submitted in partial fulfillment of the requirement for the degree of Bachelor of Science (Hons)

Resource Chemistry Programme (WS48)
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Universiti Malaysia Sarawak (UNIMAS)

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Final Year Project Report ☑

Masters ☐

PhD ☐

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This declaration is made on the 28 day of June 2012.

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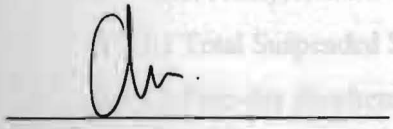

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List of Abbreviations

ANOVA	Analysis of Variance
BOD_5	Five-day Biochemical Oxygen Demand
DO	Dissolved Oxygen
HEP	Hydroelectric Project
LOI	Loss-On-Ignition method
NO_2-N	Nitrite
NO_3 –N	Nitrate
NWQS	National Water Quality Standards
OM	Organic Matter
pH	Concentration of Hydrogen ion
PO_4-P	Reactive Phosphate
PSA	Particle Size Analysis
SMSs	Sediment Management Standards
SPSS	Statistical Package of Social Science
SQGs	Sediment Quality Guidelines
TAN	Total Ammonia Nitrogen
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TS^{2-}	Total Sulfide
TSS	Total Suspended Solid
WQI	Water Quality Index

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ABSTRACT

Water and sediment quality can affect the aquatic organisms. The logging activities and the residents' daily activities brought about effect to the quality of water as well as sediment along the river. Therefore, this study was conducted to determine the concentration of water quality parameters and sediment quality parameters, then to classify them based on Water Quality Index (WQI) and Sediment Management Standards (SMSs) respectively. This study was done in 29-30th July 2015 and 3-4th September 2015 at Lio Mato and Long San respectively along the Baram river. The distance of proposed dam site to sampling areas of Lio Mato and Long San was 69.61 km and 24.21 km respectively. *In-situ* parameters were measured and the water and sediment analysis were carried out. The DO values ranged from 6.18 to 6.92 mg/L and can be classified under Class II (5-7 mg/L) under DOE WQI Classification. This showed that the water is suitable for sensitive aquatic organism. The significantly higher value of turbidity (402.4 NTU) and TSS (287.3 mg/L) in particular station 1 (Hilir Lio Mato) show that the effect of logging activities was huge and caused soil erosion. The significantly higher value of nutrient at station 5 where TN (0.120 mg/L) and TAN (0.0046 mg/L) is significantly higher than the other stations showed that residential areas or household activities contributed more to nutrient content in river water. Overall, station 2, 4, 5 and 6 were classified under Class II in DOE WQI Classification; station 1, 3, 7 and 8 were classified under Class III. There is strong relationship between percentage of sand and silt, percentage of OM and clay, TP sediment and clay with the Pearson Correlation.

Keywords: Water quality • Sediment quality • Baram river

ABSTRAK

Kualiti air dan tanah dipercayai akan menjejaskan kehidupan akuatik. Aktiviti pembalakan dan aktiviti harian orang tempatan akan membaw impak kepada kualiti air sekali gus dengan tanah di sepanjang sungai. Jadi, kajian ini ditujukan untuk mengenali parameter kualiti air dan kualiti tanah dengan menggunakan KajianAwal Indeks Kualiti Air (WQI) dan Standard Pengurusan Sedimen (SMSs). Kajian ini telah dijalankan pada 29-30 Julai 2015 dan 3-4 September 2015 di Lio Mato dan Long San yang berada di sepanjang Batang Baram. Jarak tempat sampling dengan tempat bakal membina pembekal kuasa hidroelektrik adalah sepanjang 69.61 km dari Lio Mato dan 24.21 km dari Long San. Parameter in-situ akan dijangka and analisis air serta tanah akan dijalankan di makmal. Angka DO didapati dalam lingkungan 6.18 – 6.92 mg/L dan akan diklasifikasikan sebagai Kelas-II (5 – 7 mg/L) dibawah DOE WQI. Ini telah memastikan air sungai itu sesuai untuk hidupan akuatik yang sensitif. Jumlah kekeruhan dan kepekatan pepejal terampai (TSS) di stesen 1 (Hilir Lio Mato) menunjukkan impak besar aktiviti pembalakan dan impak keruntuhan tanah. Jumlah nutrient di stesen 5 di mana jumlah nitrogen (0.120 mg/L) dan ammonia nitrogen (0.0046mg/L) adalah lebih tinggi daripada stesen-stesen yang lain. Ini menunjukkan aktiviti kehidupan orang tempatan ataupun aktiviti pembersihan rumah telah membawa kepada peningkatan jumlah nutrient di dalam air sungai. Keseluruhannya, stesen 2, 4 dan 5 telah diklasifikasikan dalam Kelas-II dibawah DOE WQI; stesen 1, 3, 7 dan 8 diklalsifikasikan bawah Kelas-III. Korelasi juga wujud antara pasir dengan kelodak, bahan organic dengan clay, fosforus tanah dengan clay melalui korelasi pearson

Kata Kunci: Kualiti air • Kualiti Sedimen • Batang Baram

1.0 Introduction

Borneo is the island which ranked as the third largest in the world and the rivers are their blood for survival. They are rich in forests and natural biodiversity. The Borneo Island is shared by Indonesia, Malaysia as well as Brunei Darrusalam and it acts as the living place as well as habitat for the orang utans and other unique species (Earth Island Journal, 2012). According to Urban Redevelopment Authority (2015), Batang Baram, which also known as Baram River, is the major river before the border between Sarawak and Brunei. State Planning Unit, SPU (2011) reported that there are two main rivers dominated the drainage of the state of Sarawak while one of them is the Baram River. The Baram River is Sarawak's second longest river and is about 400 km long. A lot of the people of Kayan, Kenyah, Penan, Saban, Kelabit and other smaller tribes are still living in the interior of Baram river. They are having the general name as Orang Ulu. Baram River is the lifeline for them living in the interior (Journey Malaysia, 2015).

Water is known to be the most important natural resource as it is the most important and valuable asset human for survival of human being; optimum utilization and good development of water resources show obvious positive changes to the overall development of a country (Akkaraboyina et al., 2012). Water quality is the most basic criteria for good river health (Office of Environment and Heritage, 2014). A healthy environment makes the water quality in the area supports a huge community of organisms and protects public health. Water quality always related closely to the surrounding environment and land use. It can be affected by community activities like agriculture, industrial as well as household activities. According to Australian and New Zealand Environment and Conservation Council (1994), the availability of fresh and clean air is unpredictable due to the fast growing population rate,

new way of farming as well as the latest need in recent industries. Water pollution may have adverse effects on drinking water supply, on the environment and on the water-related activities like tourism and fishing. The sediments or soil content from the land or forests are often transported by water deposited in streams, lakes, and wetlands. This soil material is known as sediment and disturbing activities such as road construction, timber harvesting, agriculture, housing area and commercial development will all contributed to the largest yet specific nonpoint source pollutant and the main reason in the deterioration of surface water quality (Soil in our Streams, n. d.). According to Naji et al. (2012), sediment can act as point sources of contamination during anthropogenic activities. Any aquatic programme is considered incomplete without any study of sediments. Sediment quality study is important to study the toxic contaminants present in the water ecosystem. According to MacDonald (1994), sediment quality is often used as sensitive indicator of overall environmental quality as it also influences the consequence of the existence of many toxic and bioaccumulative substances in water which act as an ecosystem for the sensitive aquatic species.

1.1 Problem Statement

Baram dam is one of the dams being proposed and developed in Sarawak. According to Sarawak Energy (2013), the development of Baram hydroelectric project (HEP) is believed to bring about advantages to the people in the inner Baram. However, the people of Baram raise their objection to the proposed project. The problems on the effects of HEP to the water and sediment quality are already an issue and a concern to the government. Moreover, there are only a few of researches done in the Baram river and hence more data on water and sediment quality are needed.

1.2 Objectives

The first objective of this study was to determine the *in-situ*, *ex-situ* water quality parameters and to classify the water according to National Water Quality Standard (NWQS) and water quality index (WQI). The second objective was to determine sediment quality and to compare them with sediment management standards (SMSs).

2.0 Literature Review

2.1 Water Quality

The activities which involve usage of land brought about impacts on the water quality. The settlements and agricultural areas were considered one of the main reasons affecting the water quality of a river. Cruz (2010) stated that the other cause of water pollution is the discharge of domestic water into the river apart from agricultural activities. The study of water quality at the Kelabit Highland of Bario stated that land clearing and timber harvesting causes soil erosions which bring about high suspended solids as the pollutants to the river water (Lau et al., 1995a; 1997). According to Ling et al. (2010), the quality of water also greatly affected by the wastewater discharged from residential area as the household water contains high content of organic matter as well as nutrients. Spalding et al. (1993) who have done the research at Sanjiang Plain, China stated that nitrate (NO_3^-) was one of the identified problematic and widespread contaminant in water environment. The major effect of nitrogen to the water environment was suspected to be the use of fertilizers. According to Cao et al. (2012), overusage of nitrogen and phosphorus causes problems such as increasing of algae, depletion of oxygen, loss of aquatic living species, depletion of biodiversity and others that affect the life of aquatic organisms and commercial industries. Previously, the study on sulfide is not so popular. Bagarinao (1992) stated that the toxicity of sulfide has caught the attention and care by the biomedical (mammalian) circle, and a few studies have been done on fishes only. Sulfide may influence the health, survival, productivity and distribution of aquatic organisms. Sulfide is also a naturally-produced substance that has been existing since the beginning of life. Hence, it is theoretically believed that all the organisms now must have been well-adapted to sulfide.

2.2 Sediment Quality

According to Batley et al. (2005), sediments are the number of substances or a possible source that dissolved and accumulated into the river water as contaminants. Sediment might contain anthropogenic pollutants and contaminants such as nutrients and heavy metals (Zhang et al., 2009). Sediment quality became an important issue to be concerned for protection of ecosystem health, fisheries conservation and surface water quality in both marine and freshwater environment (Kevin et al as cited in Babut et al. 2005; Wenning et al. 2005). According to Huh et al. (2013), the water quality groups from Korean Ministry of Environment started the development of National Sediment Management Standards (SMSs) in 2007 due to the Four Major River Restoration Project in 2009. SMSs are needed to determine contaminants content in the river water. According to Persaud, Jaagumagi, & Hayton (1993), Sediment Quality Guidelines (SQGs) is first introduced in Canada by setting safe levels for metals, nutrients and organic compounds in order to protect the aquatic environment. The guidelines were used to identify correctly at what level did the contaminants pose on the sediment and the way to deal with the problem. Toxic chemicals from industrial and municipal discharges of waste water are considered the main sources of contaminants in sediments besides the runoff from cities, town and agricultural areas (Persaud, Jaagumagi, & Hayton, 1993). According to Ling et al. (2009a), the study of sediment is essential as sediment acts as the sink for organic materials, nutrients as well as other pollutants; and eventually the longer the period of contact of sediment with water, the greater the effect on the water quality.

2.3 Water Quality Index (WQI) & National Water Quality Standard (NWQS)

The definition of water quality index (WQI) is a mean value to simplify the different yet complicated water quality data into simple version to be reported to management and the public in a fixed pattern (Akkaraboyina et al., 2012). According to Sharma et al. (2014), WQI values can be used as an indicator for human to know about the quality of water. The establishment of river quality monitoring programme in order to observe the water quality changes in river water has been done by the Department of Environment (DOE) in 1978 (DOE, 2006). According to DOE (2015), the aim is to determine the chemical and biological properties of the water samples collected at fixed intervals from the river. The water quality index (WQI) is used to identify the level of pollution and the corresponding water classes as well as uses compared to national water quality standards (NWQS) for Malaysia (Refer to *Apendix 1*). The six main parameters used to calculate WQI including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (NH_3-N), Total Suspended Solid (TSS) and pH.

The values of BOD, NH_3-N and SS continued to be significant in the determination of river pollution. The improper treatment of wastage either from human or manufacturing industries caused the high value of BOD. Presence of NH_3-N is due to the sources like livestock farming and domestic waste whereas the sources for TSS are most probably caused by improper earthworks and land clearing activities (DOE, 2015).

According to DOE (2015) NWQS, water quality is categorized into six classes. Class I to Class V indicated the beneficial uses based on the water assessment. Class I represent the best status of water quality, whereas Class IV is the worst status of water quality. Class I, II

and III are suitable for water supply and fishery with different degree of water quality. To determine the water quality, various parameters analysis can be done and used in calculating WQI by summarizing complex water quality data and utilization the water quality index can evaluate the water quality management. **Table 1** summarises the beneficial uses of water according to class.

Table 1. Water classes and uses. Adapted from "Malaysia Environmental Quality Report 2014," by DOE, 2015.

Classes	**Uses**
Class I	Conservation of natural environment Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common of economic value and tolerant species; livestock drinking.
Class IV	Irrigation.
Class V	None of the above.

2.4 Sediment Management Standards (SMSs) & Sediment Quality Guidelines (SQGs)

Huh et al. (2013). stated that the sediment management standards (SMSs) values were derived from the 95th percentile of concentration distribution for organic matter and nutrients in sediment quality database. The SMSs for freshwater sediment in Korea were set at 13 % for loss on ignition (LOI), 1,600 mg/kg for total phosphorus (TP), and 5,600 mg/kg for total nitrogen (TN). These values were found acceptable through the assessment of applicability with the datasets from locations directly affected by obvious point resources. Hence, the results indicated that SMSs for organic matter, nutrient and metals derived within the present study can use to determine the pollution level of sediment in Korea.

Ministry of Environment and Energy (1993) stated that sediment quality guidelines aim to protect the aquatic environment by maintaining accepted range for metals, nutrients (substances which related to the growth of algae) and organic compounds. The initial five levels of contamination includes background, good, moderate, bad and very bad were derived from frequency distributions of particular contaminants in the field (Kwok et al., 2013). However, there is a need to continue develop site – specific environmental quality guidelines, including SQGs. More studies will be conducted to improve the guidelines.

Besides SMSs, other guidelines are also needed to classify the sediment quality more accurately. According to Persaud, Jaagumagi, & Hayton (1993), the Sediment Quality Guidelines (SQGs) established three levels of effect which included No Effect Level, Lowest Effect Level and Severe Effect Level. The established levels believed to determine when sediment can considered to be clean; what levels of contamination are acceptable for short periods of time and at the same time the source of contamination is being controlled; what

levels of contamination are considered severe enough to consider the way to solve the problem.

3.0 Materials & Methods

3.1 Sampling Location

Overall, two sampling trips were made to Baram river, Miri, Sarawak. Baram river is 400 km long and the mouth of Baram (Kuala Baram) is located at the tip of Miri state. The first sampling area was at Lio Mato which is 206.35 km and the second sampling area were at Long San which is 161.73 km from Kuala Baram. The distance of proposed dam site to sampling areas of Lio Mato and Long San are 69.61 km and 24.21 km respectively. The date of sampling at Lio Mato was 29-30th July 2015 while date of sampling at Long San was 3-4th September 2015. Water and sediment samples were taken from four stations for each of the sampling trip. The GPS coordinates and descriptions of the sampling areas are listed in Table 2. The maps of the state of Sarawak and the sampling areas are shown in Figure 2.

Table 2: The GPS Coordinates and descriptions of the stations.

Stations	Stations Name (From Upstream to Downstream)	GPS Coordinates	Date & Time	Weather Condition	Description
1	Batang Baram: Hilir Lio Mato	N 03°10'14.8" E115°12'53.1"	30/7/2015 16.11	Sunny	Main river, Long houses at the downstream
2	Long Selaan	N 03°05'49.9" E115°04'52.5"	29/7/2015 12.59	Heavy rain during midnight; Sunny during sampling	Tributary: Long houses, Logging
3	Batang Baram: Hulu Long Moh	N 03°03'40.3" E115°04'39.4"	30/7/2015 11.44	Sunny	Main river, Logging, Plantation of paddy is developing